Sustainable consumption, energy and failed transitions: the problem of adaptation

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INTRODUCTION

Theories of socio-technical transitions provide two principle advantages for the analysis of sustainable consumption: a multidecade, multiscale approach that enables long-term, systemic thinking in a comparative perspective; and an integrated analysis, in the tradition of technology studies, of the social and technical aspects of the design and development of large-scale technological systems, including infrastructures (for example, Hughes, 1987). The approach has been used to study how to manage long-term changes in socio-technical systems to make them more sustainable (for example, Jørgensen and Sorensen, 1999; Smith et al., 2010; Geels, 2011). However, there is growing recognition that sustainability transitions are occurring at a pace that is too slow to stop or reverse the worst effects of human societies on natural systems. As a result, there is a need to analyse more carefully not only the problem of how to achieve a sustainability transition but also the implications of transition failure. This study will examine the thesis that the failure to address significant global environmental problems in a timely way has resulted in an ensuing shift toward an adaptation transition. The emergence of an adaptation transition has significant policy implications for the management of the sustainability transition, including sustainable consumption.

The rise of severe weather events associated with climate change has forced societies into investing growing resources into disaster response and adaptation strategies for climate change. In many countries, subnational governments such as cities and states now have adaptation plans in addition to sustainability plans. In effect, the failure of the sustainability transition has forced governments to engage in an adaptation transition. Because resources are limited, the allocation of funds to adaptation can occur in a zero-sum relationship with potential investments in sustainability such as the greening of electricity systems, buildings and transportation. However, there are also new opportunities that emerge in the design of technological systems that can address both adaptational and sustainability concerns. By doing so, it becomes possible to rethink sustainable consumption by exploring policies associated with sustainable consumption in relationship to adaptation goals.

The argument is made in three sections: an introduction to the concept of a failed sustainability transition and its implications for studies of socio-technical transitions; an analysis of the concept of resilience as central to the study of adaptation transitions; and a demonstration of how adaptation and sustainability goals can be brought into alignment in the case of policies governing energy efficiency and distributed renewable energy generation. The goal is to show not only the potential for the alignment of adaptation and sustainability goals in the design of socio-technical systems but also how concerns with adaptation and resilience may also inform and improve research and policy on sustainable consumption.

TRANSITION STUDIES, LANDSCAPES AND THE FAILURE OF THE SUSTAINABILITY TRANSITION

Before discussing the relationship between the adaptation transition and sustainable consumption, it is first necessary to discuss differing approaches to sustainability and some features of multi-level analysis of sustainability transitions (see the chapter by René Kemp and Harro van Lente in this volume). Sustainable consumption researchers have tended to work with a concept of sustainability that is based on the tradition of intergenerational equity in the Brundtland Report (WCED, 1987). For example, the European Environmental Agency (EEA) defines sustainable consumption as ‘the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations’ (EEA, 2010; for a review of the literature, see Cohen and Murphy, 2001; Jackson, 2006). Unfortunately, the approach to sustainability in the Brundtland tradition does not draw attention to the relationship between societal change and ecosystem adaptation. For that reason, the approach to sustainability developed by ecological economist Herman Daly (1990, 1996) is more appropriate to the problem of the failure of the sustainability transition and the emergence of the adaptation problem. He defined sustainability in terms of the capacity of an ecosystem to replenish consumed resources and process wastes. Although the definition lacks the intergenerational equity perspective of the United

Nations' approach, it draws attention much more to the ecological limits of a society and the overall problem of the adaptation of society to its ecosystem (including at a global scale).

The Daly approach to sustainability can be used to expand on the multi-level analysis of transition studies by providing the basis for modifications of the concept of the 'landscape.'[1] Although the landscape can include society-environment relationships, the implications of those relationships are central to the study of sustainability transitions. To understand the implications of the failure, one must disaggregate the category of 'landscape' that is commonly used in transition studies, because there is an important feedback loop between human systems and environmental degradation. The slow pace, and in some regions even outright failure, of the sustainability transition has created environmental changes that have political and economic repercussions, because increasing levels of resources must be devoted to environmentally related disaster management and adaptation measures. Thus, there is potential for a negative feedback loop to develop. In other words, the failed sustainability transition could force societies to devote increasing resources to adaptation measures, which can come at the expense of additional investments in the sustainability of infrastructures and other socio-technical systems.

Unlike historical comparison cases of other transitions in large-scale socio-technical systems, in the case of the sustainability transition the relationship between the society and the ecosystem changes as a result of the success or failure of the transition. For example, a delay of 50 years in the transition from steam-powered ships and trains to diesel power would have had societal consequences, but the society-ecosystem implications would probably have been negligible in terms of issues such as greenhouse gases, because of the relatively low levels of steam-energy consumption in transportation during that time period. However, a delay of 50 years today in the transition from fossil fuels to low-carbon energy will have dramatic effects on global warming and other environment-society feedback loops. Although the economic and technical outcome of a failed green energy transition may be business as usual (in the sense of continuing growth in energy consumption and ongoing use of fossil fuels), the landscape and ecosystem relations are transformed by the slow, and in some cases blocked, transition to low carbon energy and other technologies associated with reduced environmental impact.

The failure of the sustainability transition implies that governments throughout the world will be turning increasingly to the problem of climate adaptation rather than climate mitigation and sustainable consumption. (One can focus on climate, but it should be understood that there are many other issues of environmental degradation, such as the depletion of aquifers, that result from failures to transition a society to a more sustainable relationship with the ecosystem.) Although something approximating a green energy transition that goes beyond a reduction in carbon intensity will continue to be found in some countries, even in some North American states and provinces, those changes will coincide with the adaptation of socio-technical systems to increasing ecosystem stressors caused by climate change and general ecosystem degradation. For example, in the United States several state governments have already put in place a climate adaptation planning process (Cruce, 2009). Governments will not have a choice to defer investments in adaptation, because climate change will increase the frequency of weather-related disturbances such as severe droughts, floods, ice storms and snowfall that will require an immediate response. Likewise, general resource and food shortages due to land-use policies, economic growth and population growth will create related crises of adaptation. Where resources are not drained in immediate-response mode, preventative resources will be oriented increasingly toward short-term adaptational needs. In many areas of the world, water management and associated land-use politics will become pressing issues, because governments will need to respond to issues of water shortages and floods that have emerged from the interaction of climate change and land-use patterns. In short, alongside the uneven, mitigation transition toward more sustainable systems, there will be another, also uneven, transition toward adaptation to climate change and other ecosystem stressors.

The second major conceptual modification in transition studies for the concept of the landscape involves the need to understand macrosocial political change or stasis not as an exogenous variable but as a dynamic field of interactions characterized by relationships of cooperation and conflict across different levels of government and policy arenas (Fligstein and McAdam, 2011). For example, in the United States, some state governments have developed renewable electricity standards, building-efficiency standards, and various tax credits and financing mechanisms to support the retrofitting and solarization of buildings, but the federal government has failed to enact a basic policy framework such as a renewable electricity standard and a cap on carbon emissions. It has also failed to utilize its position of global economic and political power to develop international agreements to reduce greenhouse gas emissions and to bring the aggregate levels of consumption of the world down to the level of planetary carrying capacity. Instead, within the country a well-funded industry network has fanned skepticism about climate-change science and hostility to green-transition policies, and on the international stage the government has worked to block reforms proposed by other countries. Thus, one finds that the sustainability transition is not only a failure in an ecological sense (in terms of moving at a rapid-enough pace to bring the world’s consumption into a Daly-type condition of sustainability), but also uneven (across policy fields governing different technologies and across scales of government).

Case studies of transitions have recognized the emergence of resistance and industrial opposition as part of the transition process (for example, Geels, 2002, 2005). However, historical cases do not always provide a good sense of political conflicts that characterize the sustainability transition in the twenty-first century. The level of sophistication in the resistance to the sustainability transition is considerably higher than in cases such as the transition from horse-drawn vehicles to automobiles. In the United States, the fossil fuel industries have effectively utilized conservative foundations and conservative political organizations to mobilize a broad movement that has reframed the green energy transition as without scientific basis, socialistic and too expensive in a time of economic hardship (Dunlap and McCright, 2011). The rapid and effective counter-mobilization to the green-jobs programs of the first two years of the Obama administration has all but ended any hope of reform on the part of the federal government. The 2010 elections brought to power a wave of anti-green legislators at both the national and state levels. Although reforms have continued in a few states where Democratic Party majorities were retained and governors backed green energy, the overall progress of a green energy transition in the United States is blocked (Hess, 2012).

Furthermore, counter-mobilizations have altered the political culture of sustainability politics by embedding them in ongoing ideological contestations over neoliberalism and social liberalism. In contrast with other socio-technical transitions (such as the shift to internal combustion engines), the sustainability transition requires complex government intervention and planning, because of the problem of impending ecosystem destruction and the need to coordinate the transition of multiple socio-technical systems. The kinds of engagement are more complex and more time-sensitive than the rule-making of regimes associated with, for example, the creation of roads for automobiles or licenses for electricity-transmission lines, in which maturing entrepreneurial organizations and market-driven investments could play a more substantial role. However, the need for government intervention and planning itself has become a central area of contestation in the sustainability transition, thus embedding sustainability politics in ongoing political tensions and debates involving political ideology.[2]

Even in countries where industrial control of the political field and ideological debate is more limited, the situation is only superficially more positive. For example, China has a clear national plan to increase renewable energy and nuclear energy, but it is within the context of overall energy growth. Goals are framed in terms of energy intensity (consumption per unit of gross domestic product) rather than absolute reductions in energy consumption. Consequently, although headlines point to increases in renewable energy production, the current five-year plan allows coal-based energy output to increase as well (Seligsohn and Hsu, 2011). The pattern for China also extends globally; research by sociologist Richard York has shown that although renewable energy production has increased, each unit of growth in nonfossil fuel sources of electricity generation has only displaced one-quarter unit of fossil fuel consumption. Like the Jevons paradox, which shows that efficiency gains can lead to increases in consumption, York's research suggests that an increase in renewable energy does not lead to a one-to-one decrease in fossil fuel consumption (York, 2006, 2010, 2011; see also Herring, 2009).

In summary, the sustainability transition is a political and historical event in which the 'landscape' (in the sense of the long-term, macrosocial processes and changes in society-ecology relations) is itself changed fundamentally by the pace of the socio-technical transition. To develop social science research that can effectively guide policy, it is necessary to have a conception of the landscape as including the dynamic interaction of human and natural systems and as comprised of a contested political field in which power and ideology are central features. The transition to more sustainable socio-technical systems, and corresponding levels and forms of consumption, is also different from many other prior transitions because it requires significant government planning, has a very sophisticated machinery of industrial opposition and is in a state of failure. There are some positive examples of national and subnational governments that are making progress, but the aggregate level of fossil fuel and energy consumption is increasing. In turn, the failure of the transition creates feedback loops that provoke a forced adaptation transition. Because budgets are limited, there is potential for a zero-sum relationship to emerge between the adaptation transition and the sustainability transition. In the long term of a half-century or more, there may be significant progress toward a green energy transition and the decarbonization of the global economy. But in the short term of the first half of the twenty-first century, overall growth in consumption is likely to swamp the slow pace of the sustainability transition. As a result, governments and other organizations will be increasingly forced to respond to problems of adaptation. Research on sustainable consumption will need to incorporate the broader landscape changes involving adaptational pressures to develop policy guidance that is effective in contested political fields.

ADAPTATION, SUSTAINABILITY AND RESILIENCE

The initial configuration of the relationship between climate adaptation and mitigation policies may likely be zero-sum because of limited budgets, but is that the only possible relationship? In other words, can a design perspective on socio-technical systems enable policy makers to develop a positive-sum relationship between adaptation and mitigation? Certainly, the forced transition toward more well-adapted technological systems creates a new political opportunity structure that may be restrictive for advocates of policy reforms for green energy and sustainable consumption. However, it may be possible to design socio-technical systems that integrate the goals of climate adaptation and mitigation. For example, a region that has an urban waterfront on a flood plain may need to expend significant resources to build floodgates, canals and dikes, but it can also explore land-use patterns upstream that both enhance water retention and reduce atmospheric carbon dioxide (CO_2), such as reforestation, more dense development patterns, rain gardens and green roofs. Likewise, in some cases cities that have faced the prospect of rebuilding after a disaster have used the opportunity to construct more sustainable infrastructure (Postgate, 2009).

Just as the primary theoretical concept for thinking about climate change mitigation strategies is sustainability, the primary theoretical concept to date for thinking about ecological adaptation and socio-technical systems is resilience. Resilience is the topic of a substantial literature, including in engineering, security, corporate strategy and socio-ecological systems (see, for example, Berkes et al., 2002; Walker et al., 2004; Sheffi, 2005; Peters, 2008; Cascio, 2009). The common ground that is the basis for the use of the term here is the capacity of a system to maintain essential functions when faced with disruptive perturbations. Increasingly, the literature has also explored issues of resilience with respect to urban policy and design (for example, Newman et al., 2009), and much of the work on resilience and cities is concerned with responsiveness to disasters (for example, Tobin, 1999; Godschalk, 2003; Vale and Campanella, 2005; Rose 2007). Although disaster planning and sustainability are very distinct topics, they come together as a result of climate-related weather instability and general environmental decision making, such as land-use regulations, that affect water flow and quality.[3]

This section focuses on the design of socio-technical systems and its implications for making consumption more sustainable. Decisions by households and organizations about their consumption patterns take place within broader industries and socio-technical systems such as electricity, buildings, transportation and food. The design of those[D1] systems establishes frameworks that shape consumer decisions and options, just as consumer decisions also shape the changes that occur in technological systems (Rohracher, 2003; Van Vliet et al., 2005). Thus, the focus on the design of socio-technical systems – in the broad sense of the design of technical features and of organizational, legal and user-technology relationships – is an important aspect of sustainable consumption.

In general, whereas a mitigation perspective seeks design changes that modify socio-technical systems in a sustainability direction, an adaptation perspective modifies socio-technical systems to increase their resilience. For example, in the case of energy supplies, a system is more resilient if it has multiple sources of energy, backup energy sources and local storage. In the case of transportation, the perspective would open political opportunities for the use of alternative fuels, but it might close opportunities for the complete greening of a fleet that is reliant on a single type of energy source (such as electricity from grid-based renewable energy to power both consumer vehicles and public transit fleets). Likewise, for building-energy systems, a resilience perspective would open opportunities for distributed renewable energy because it increases the diversity of energy generation, but it would also recognize the importance of energy storage, multiple types of energy sources (including fossil fuels and renewable energy) and the mixture of both centralized and distributed energy production. In the case of food, a resilience perspective would open opportunities for some localization, but it would balk at complete localization, which would create risks for supply disruption in the event of disasters.

The adaptation transition can potentially open opportunities for the greening of socio-technical systems, but it can also pose limits on the extent and configuration of the greening of a system. To the extent that the greening of a socio-technical system narrows the sources of energy (such as to all solar or renewable energy), it increases the exposure of the system to supply disruptions and decreases the system's resilience. Here, a resilience perspective suggests a change in its pathway of transition toward reconfiguration in the direction of diversity. Conversely, from a sustainability perspective, it may appear to be undesirable to increase the resilience of a system that is based on less sustainable technologies such as fossil fuels. Instead, a sustainability advocate may wish to see lower resilience in older systems to hasten their demise.

The greatest zone of compatibility between resilience and sustainability perspectives in systems design is with the reduction of consumption; reduction both eliminates a drain on resources and the need for resources in the event of a challenge to system resilience. The greatest zone of potential conflict is with highly efficient technologies that are reliant on a single source of inputs and can reduce storage capability, because the reduction of diversity and storage can lead to a reduction in resilience, and an increase in resilience may result in a larger ecological footprint. For example, in the cases of fuels and electricity, a resilience perspective could include a continuing role for fossil fuels, at least as a backup stream of energy sources that improves overall system robustness and flexibility.

The analysis to this point remains focused on the technical issues of system design, or what I term 'material' resilience. A fully sociological approach to the understanding of the relationship between adaptation and sustainability transitions must also include an economic form of resilience. At the household level, material resilience refers to the capacity of a domestic unit to maintain its physical state of resource use, whereas economic resilience refers to its capacity to withstand economic shocks and the economic dimensions of material shocks such as natural disasters (Hess, 2010). Various strategies can increase the economic resilience of a household, such as savings, multiple jobs and social networks. In a similar way, one can also think about the economic resilience of a city or metropolitan area.

The concept of economic resilience is not widely discussed in the literature on cities, and where it has been raised, the focus has been on the capacity of an economy to replenish capital stock in the event of a disaster (for example, Rose, 2007). Although the literature does discuss the economic implications of natural disasters at a city or local level (for example, Cohen 1996; Hallegatte et al., 2011), it has mostly focused on material resilience as a strategy of adaptation, such as changes in land use, zoning in flood plains and infrastructure for stormwater. Economic resilience also should be included as part of the adaptation strategy. Economic resilience can be enhanced by putting in place policies that increase household-level economic resilience, such as by encouraging savings and providing resources for part-time and second jobs. However, an urban or regional resilience approach could also include strategies that make the regional economy as resilient as possible, that is, as capable of withstanding economic shocks as possible. One strategy is to develop a regional innovation system that is capable of creating new technologies and products that can adapt quickly to global market conditions (Cooke, 2008) (see the chapter by Jennie C. Stephens and Stephen M. McCauley in this volume). For example, the economy of Silicon Valley is resilient in the sense that it has been able to develop new industries in response to global economic change. Another strategy is to increase locally owned, independent businesses, because they are unlikely to leave the region and are more likely to purchase from other local businesses (Hess, 2009). Although this point cannot be developed here, a resilient regional economy requires both a regional innovation system and a strong sector of locally owned, independent businesses. That economy can also be made consistent with the development of green businesses (Hess, 2012).

With this background discussion of the concept of resilience in mind, it is now possible to analyse how the politics and design of adaptive systems can be brought into alignment with a sustainability approach. The next section will show that when one brings questions of adaptation and resilience into socio-technical system design (which governs the limits and possibilities of consumption), a much deeper analysis of design is made possible than one purely focused on sustainability criteria. Thus, it may be possible to use the perspective developed here to formulate sustainable consumption policies that are more effective both technically and politically.

ENERGY EFFICIENCY AND DISTRIBUTED RENEWABLE ENERGY GENERATION

Because the transition to a green energy or low carbon economy is central to the sustainability transition, the sector of buildings and energy is a good choice for the study of the relationship between resilience and sustainability. The sustainability transition ideally involves both the reduction of energy consumption and the greening of the type of energy consumed. For example, the transition to sustainable consumption for a building entails increased levels of energy efficiency (EE) and increased levels of renewable energy (RE) consumption. From a sustainability perspective, the main way to analyse the relationship between the strategies is to look at net reductions in a building's ecological footprint (such as how much carbon is saved by an EE or RE shift) and compare them with cost. From a carbon-accounting perspective, it matters little if the RE is supplied over the grid or if it produced on a rooftop; likewise, it matters little where the EE gain is achieved (in an air conditioner versus a refrigerator), provided that lifecycle gains and rebound effects are equivalent. Even the tradeoff of an EE and RE gain can be analysed in terms of the net reduction of carbon emissions caused by either. Because the focus of attention is on the ecological footprint of a building (for example, operationalized as a reduction of net carbon emissions), many kinds of design choices become technically neutral or black boxed. In other words, an orientation based purely on carbon mitigation or a similar framework is neutral with respect to choices such as rooftop versus grid energy, savings in air conditioners versus refrigerators and so forth, provided that the savings bring about equivalent net reductions in carbon footprints without differential rebound effects. There is a *ceteris paribus* aspect to a purely mitigational perspective that offers little additional guidance on many system-design choices.

However, from an adaptation perspective, other issues become important. In a cold climate, an EE improvement to the heating system is arguably the most important among possible EE changes, because it reduces demand on backup systems in the event of a power failure. Likewise, insulation and weatherization provide temporary resilience in the event of a disruption of energy flow to the building. Distributed renewable energy (DRE, defined as on-site energy generation that is connected with the electricity grid) that has localized storage and a grid connection provides a much higher level of resilience than grid-supplied renewable energy, because the building is prepared to obtain power both from the grid in the event of a system failure of the DRE and from the local system in the event of a failure of the grid. Furthermore, the relationship between EE and DRE is not neutral. Because no amount of EE will be helpful in the event of a power outage, DRE is arguably preferable to EE from an adaptation perspective. In summary, with respect to the consumption of energy by buildings, the adaptation transition will tend to open political opportunities for DRE relative to EE, and it will also alter the preferences within DRE and EE. Thus, an adaptation perspective reconfigures the decision-making criteria for EE and DRE interventions, many of which might otherwise be seen as relatively neutral tradeoffs when the goal is reducing net greenhouse gas emissions from a building.

DRE generation is of general interest for the study of the relationship between the adaptation and sustainability transitions because it has the capacity to serve as a boundary object, that is, as a vague area of convergence that enables political coalitions to form and policies to be built with respect to both mitigation-sustainability and adaptation-resilience transitions (Star and Griesemer, 1989; Hess, 2007). Some forms of DRE and EE can enhance the material resilience of a building but also achieve sustainability goals. Furthermore, to the extent that installation and construction businesses are locally owned, economic resilience for a regional economy (as defined above) can also be enhanced, because expenditures going out of the regional economy for nonlocal energy are captured for recirculation in the local economy (Hess, 2009, 2012). To the extent that the markets for DRE and EE are connected to local technology innovation and manufacturing, they could also be part of a system of regional innovation that increases the resilience of a regional economy.

The following will compare policies for encouraging the financing of DRE and EE at the state and local government level in the United States. Although the suite of policies involving net metering, grid-interconnect standards and licensing of DRE and EE contractors is important, the section will focus only on the policies that provide the financing and other support for building owners who seek to add DRE and EE. To clarify, the policies operate at the interface of a sustainability and adaptation transition; hence, they can be understood as policies that affect sustainable consumption as well as the material resilience of buildings and the economic resilience of building owners. Although there are many barriers to the successful implementation of building-level EE and DRE policies, this analysis will focus on the financial and ownership structure of the programs, because that aspect is where the resilience issues become especially salient.[4]

There are two standard ways to finance DRE and EE improvements. First, third-party agreements rely on private sector investment to fund and maintain DRE such as rooftop solar. The installation is owned by the company rather than the building owner, but the building owner usually receives the benefit of reduced energy costs based on the cost of producing the distributed energy. At the end of the agreement period of 6 to 25 years, the building owner may renew the arrangement, purchase the installation or allow the company to retrieve the equipment. Third-party agreements have the advantage of passing installation and maintenance responsibility over to another party and of stabilizing long-term electricity rates based on DRE, but they achieve the advantages at the loss of local ownership. At the end of the lease, the building owner has nothing other than potential accumulated savings, and economic resilience for the owner has not improved. The service provider generally does not pay for the cost of on-site DRE storage, such as batteries, and consequently there may be few opportunities to increase the material resilience of the building.

A second standard approach is a government-sponsored incentive for DRE and/or EE in the form of tax credits, rebates and loans. The programs are often funded by a system-benefits charge and administered through a state-government agency in partnership with a nonprofit organization and electricity utilities. In effect, the programs represent a transfer from all ratepayers to those who take advantage of DRE and EE potential. The transfer is potentially regressive (a point not lost on conservative opponents) unless it is accompanied by a low-income energy program. The building owner (either a homeowner or commercial building owner) must contract for the energy audit, arrange for the contractor to do the work and set up the financing arrangement if a loan is used. Rebates and credits also require an up-front investment of capital, and loans increase the debt load that can affect the credit of a household or business.

Government-sponsored programs have several advantages over third-party agreements. First, these initiatives often combine DRE and EE incentives, and consequently they are broader in scope. Second, the programs result in a transfer of ownership of electricity generation to the building owner, either in the form of DRE generation or in the more implicit form of energy not consumed because of conservation. Over time, the building owner achieves a positive return on investment (a potential increase in economic resilience) but also has increased material resilience in the form of improvements to the building. Finally, the programs are open with respect to the building owner's preference to include on-site storage and direct generation for the building.

In comparison with third-party agreements, the rebate and loan programs offer greater leeway for enhancing resilience. Economic resilience is increased because the building owner eventually owns a greater portion of the electricity consumed, and the owner is less subject to exogenous price shocks. Furthermore, because the building owner also owns the DRE, it is easier to connect the DRE with on-site storage. That consideration plus the energy-conservation benefits of EE incentives result in lower material dependence on grid-supplied electricity. Thus, there is a valence in local ownership toward increased economic and material resilience for the building.

Although government incentives have been successful, they have several drawbacks that a new generation of DRE and EE financing policies has attempted to address. If a building owner wishes to sell the building, the long-term horizon of the return on investment makes the investment illiquid, and it may not be possible to recoup the investment with an increase in the selling price for the building. The reduced liquidity of the building owner is, in the terminology used here, a factor that reduces economic resilience. Another drawback is the transaction cost associated with finding a contractor and supervising either a DRE or EE building-improvement project. In general, the programs require a fairly knowledgeable person who is willing to work through the maze of government requirements and to supervise a contractor on a building.

For a short period of time, residential property-assessed clean energy (PACE) bonds represented a financial innovation that solved the problems of long-term liquidity. The basic innovation of PACE financing is that the long-term payment on the DRE or EE improvement becomes part of the property tax of the building, so that it can be passed on to new owners. In some cities in the United States, PACE programs for a time provided an 'energy concierge' who helped to reduce transaction costs by guiding building owners through the bureaucratic process. In terms of an adaptation perspective, PACE financing increased economic resilience by making the building investment more liquid in the event that the owner decided to sell the building.

PACE programs grew at a rapid rate after they were first introduced in 2008. Within two years, such initiatives had been approved in half of the states, often with bipartisan support, and in 2010 the federal Department of Energy awarded hundreds of millions of dollars to the programs. The California program was especially large, with over 100 cities poised to participate. However, in May 2010, the Federal Housing Finance Agency (FHFA) ended residential PACE programs because it was concerned that a city's lien was senior to the mortgage instruments that federal agencies held. Although it is commonly assumed that PACE programs died with the FHFA decision, the decision did not apply to commercial buildings. Some holders of commercial mortgages allowed PACE financing, and some banks saw the program as a financial opportunity for new, creditworthy loans (IBE, 2010). PACE financing for commercial buildings was potentially very large, with estimates as high as $2.5 billion annually by 2015 (Pike Research, 2010). Another option that has emerged is the state of Maine's 'junior lien' arrangement for property-based financing for residential homes. Legal under the FHFA ruling, over 100 cities had adopted ordinances to enable the new PACE loans by the end of 2011 (Efficiency Maine, 2011). Cities were also developing commercial PACE programs, and some states were developing 'on-bill financing,' which refers to programs that allow borrowers to pay back a loan for DRE or EE projects as a line on their utility bill. The loan can be attached either to the property, therefore staying with the building when it is sold, or to the owner, who must pay off the loan when the building is sold. The former approach is most similar to PACE, because it provides the desired liquidity in the event of an unplanned sale.[5]

Because PACE-type programs and on-bill financing recoup investments so that new loans can be made with repaid loans, the economic resilience of the program is greater than for rebate schemes, which simply expend funds on a one-time basis. Furthermore, the programs enhance the economic resilience of a building owner, because they increase liquidity in the event of a forced sale but do not require up-front investment. Moreover, the building owner can sell surplus electricity back to the grid. The programs have a valence toward increased material resilience over power-purchase agreements because the localization of ownership provides building owners with increased leeway to build the systems in ways that are connected to on-site storage.

DISCUSSION

In summary, an adaptation-resilience perspective creates distinctions that would appear to be neutral or unimportant from a purely sustainability perspective. Those differentiations emerge both in the technical design of system features (choices between and within EE and RE design improvements) and in the design of financial policies that are intended to increase sustainable energy consumption by building owners. Although there are many ways in which adaptation and mitigation policies can be in tension, the example discussed here shows that they can also be brought into fruitful synthesis.

From the perspective of enhancing the sustainability of energy consumption of building owners, there is general recognition of the distinction between two main approaches to energy consumption: energy conservation and greener forms of energy consumed. Policies that favor the installation of DRE replace grid-based household consumption with local solar energy, but they do not necessarily reduce the overall level of energy consumed per household or commercial building. In contrast, EE programs can result in a reduction of household energy consumption, such as fewer kilowatt hours or therms consumed per month for the same household, but they do not address the emissions levels of the remaining electricity that is consumed. Together, DRE and EE approaches to a building could result in positive synergies that reduce the building's overall carbon footprint, provided that rebound effects are controlled.

In contrast, from the perspective of increasing the building's resilience in the face of adaptational stressors, new questions emerge that make the analysis of DRE and EE policies more complex. For example, EE installations do not provide the same level of improvement in material resilience as do DRE installations. If the DRE is connected with local energy storage, such as in the case of rooftop solar with battery storage, then it provides strong material resilience in the event of an electricity outage, whereas EE installations do not help much because they only reduce the need for electricity. However, with respect to the economic resilience of the building owner, EE installations tend to provide a more rapid return on investment, and they are often considered the low-hanging fruit of the greening of buildings. As a result, it is possible that EE would be favored over DRE from an economic resilience perspective even if it would not be favored from a material resilience perspective. There are also differences in the resilience implications within EE or DRE installations. DRE installations that lead to long-term local ownership provide the building owner with greater long-term economic resilience because an asset is acquired over the long term, whereas third-party agreements do not provide the same benefit. Likewise, DRE installations that are financed through a PACE bond or on-bill financing that is tied to the building also increase economic resilience because they allow the building owner to have a better chance at recovering the investment in the event that the property must be sold.

A combination of sustainability and resilience perspectives provides a more holistic analysis of DRE and EE policies. It also may provide a source of hypotheses to test when studying problems of program implementation. For example, the often-discussed problem of conversion of audits into implemented improvements may be better understood if the effects on economic and material resilience for the household or business are added to the analytical framework. There may also be intangible, noneconomic benefits associated with local ownership and control over the systems that a concept of material and economic resilience helps to articulate.

CONCLUSION

The multiscale, long-term, socio-technical approach to sustainable consumption found in transition studies has enormous benefits. However, the difficult problems of the unevenness and, from a global ecosystem perspective, failure of the sustainability transition draw attention to ways in which transition studies of sustainability can be modified and improved. The ecological ramifications of a slow, uneven and in some cases outright failure to engage in a sustainability transition requires a complex assessment of the ecology-landscape relationship, which in turn benefits from a concept of sustainability that is closer to the Daly approach than the Brundtland approach. As the failure of the sustainability transition deepens, adaptational demands will increase on political and economic systems as well as on consumers. A forced transition, the 'adaptation' transition, will require immediate resources that will potentially drain away resources for investment in sustainable technological systems.

Although the sustainability and adaptation transitions are potentially on a collision course, the relationship is not necessarily zero-sum. A more complex relationship is possible, because the politics of adaptation both open and reconfigure the political opportunity structure for the politics of sustainability. Likewise, the rather modest and uneven progress of the sustainability transition creates opportunities to design more resilient socio-technical systems. In the specific case of energy consumption for buildings such as households and businesses, resilience concerns pose different questions that reconfigure the range of policy interventions to make the energy-consumption patterns of buildings more sustainable. Furthermore, by pushing the conceptualization of resilience further to include both material and economic resilience, it becomes possible to identify new ways in which sustainability interventions might be made more effective.

This analysis is not intended to cover over the rather gloomy prognosis that the transition to a more sustainable society and economy at a global level is occurring too slowly to halt the worst effects of human societies on climate change and environmental degradation. Rather, it is meant to point to a way of assessing the changing politics of the political and economic landscape that has created an alternative adaptation transition and reconfigured the political opportunity structure for the politics of sustainable consumption.

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NOTES

1. The multi-level perspective within transition studies includes niches, where new technologies are incubated; stabilized, large-scale socio-technical systems and governing regimes; and broader landscapes of socio-cultural change (see the chapter by René Kemp and Harro van Lente in this volume). Transition studies researchers have recognized the lacunae of a relatively undertheorized landscape and underdeveloped concept of power as areas for which further theoretical development and empirical research is needed (for example, Geels, 2002, 2007, 2011; Avelino and Rotmans, 2009).
2. Naomi Klein (2011) has also made the general argument that the problem of addressing climate change requires government intervention and therefore has, in itself, ideological and political implications.
3. Smith and Sterling (2008) also see potential for thinking about socio-technical systems and sustainability from a resilience perspective. My approach focuses more on contrasts and tensions between resilience and sustainability goals.
4. This section is based partly on research conducted during the summer of 2010 on DRE and EE financing policies at state and local government levels (Hess et al., 2010). The research project involved eight graduate students who developed case studies of green jobs and green economic development policies in approximately two dozen states and cities in the United States. Their work included some interviews about DRE and EE policies, as well as attendance at conferences and analysis of government documents and policy reports. The discussion that follows builds on the empirical base of these interviews and analyses by examining in more detail the financing policies for DRE and EE at state and local government levels. For a review of the policies, see Fuller et al. (2010).
5. More detailed discussions of the different financing approaches are in Farrell (2010a, 2010b), Hess (2012) and Van Nostrand (2011).

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